OBSERVATION OF JAPANESE PADDY RICE FIELDS USING MULTI TEMPORAL AND POLARIMETRIC PALSAR DATA

PI No.365

Naoki ISHITSUKA[1], Genya SAITO[2], Fan YANG[3], Chinatsu YONEZAWA[4] and Shigeo OGAWA[5]

[1]National Institute for Agro-Environmental Sciences
[2]Japan Aerospace Exploration Agency
[3]University of Tsukuba
[4]Tohoku University
[5]National Institute for Rural Engineering

1. INTRODUCTION

In agricultural areas, changes on the ground surface may be rapid and more dynamic than those in forests. Major farm products may be harvested within a few months or less than a year. Therefore, it is important that timely observations be carried out in agricultural areas. When using optical sensors, because they are influenced by weather, the availability of "timely" observation may be difficult. On the other hand, Synthetic Aperture Radar (SAR) can observe rainy and cloudy weather, and is capable of producing “timely” observations of agricultural land.

Rice is staple food of Asia. Thus monitoring the area of rice is demanded. Remote sensing is suitable to determine the acreage of paddy rice fields. However almost regions of rice product have rainy season. Thus SAR is expected to use monitoring paddy rice fields.

In Japan, the consumption of the rice is decrease and rice is surplus. Therefore the government and farmers control amount of products. One of the production control methods is planting different crop in the nominal paddy fields, for example wheat, soybeans etc. Thus rice is not planted in all paddy fields. Nationwide, more than 30% of paddy fields are no longer planted with rice (approximately 1 million ha). Therefore the government wants to method that detects paddy rice planted area.

The purpose of the research is to clarify the problem and effectiveness when measure the planted area of rice paddy fields using ALOS/PALSAR, which is the first in the world L-band multi polarimetric satellite SAR sensor. In addition we compare the multi temporal PALSAR data with the ground survey data of the rice growth, to check the potential of rice growth monitoring.

2. DETECTION OF RICE PLANTED AREA

2.1 WINTER PADDY RICE FIELDS

2.1.1 Data used and study area

Fig 1 is an ALOS/PALSAR image in the vicinity of Aichi Prefecture taken image on February 19, 2007. The observation mode is descending, the HH polarization, and the off nadir angle is 34.3 degrees. Lake Hamana is on an image right edge, there is Chita Peninsula in the left end, and the Atsumi peninsula is seen at the center of the lower side. The Atsumi peninsula is region of agriculture in suburban areas.

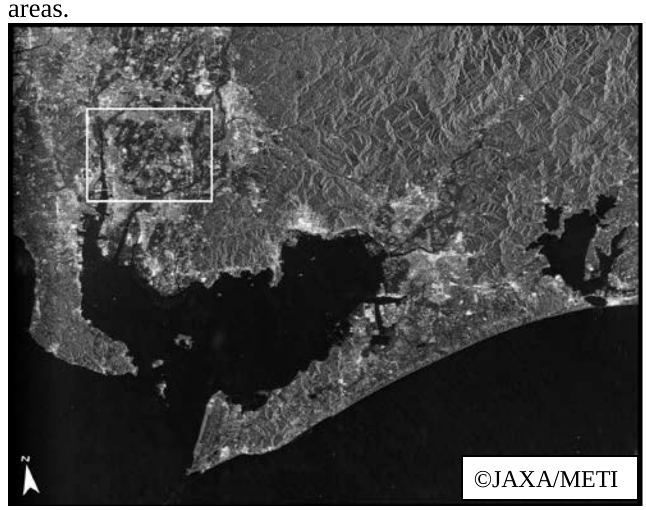


Fig 1. ALOS/PALSAR image in the vicinity of Aichi Prefecture on February 19, 2007

2.1.2. Ground truth

The fields survey is done from 20th to 21st in February, the next day of 19 February when PALSAR was observed, and the ground truth data is taken. The ground truth carried out checking ground state with GPS camera. In this study, we compare ALOS data with ground truth data.

2.1.3. Results and discussion

Fig. 2 is an expansion image, the vicinity of Anjo City, rectangular of Fig. 1. The parts, which look bright white, are urban areas, on the other hand, the parts which look dark are water bodies and farmland in Fig. 2. Those farmlands are paddy rice fields, upland fields and the fruit tree (fig, Japanese pear).

The reason why most farmlands look dark is low backscatter. It is known to look dark well in SAR image so that the microwave may cause the specular reflection when the surface of the water observes. The paddy rice fields and the upland fields are usually not filled water because this image is winter. However, almost fields look dark.

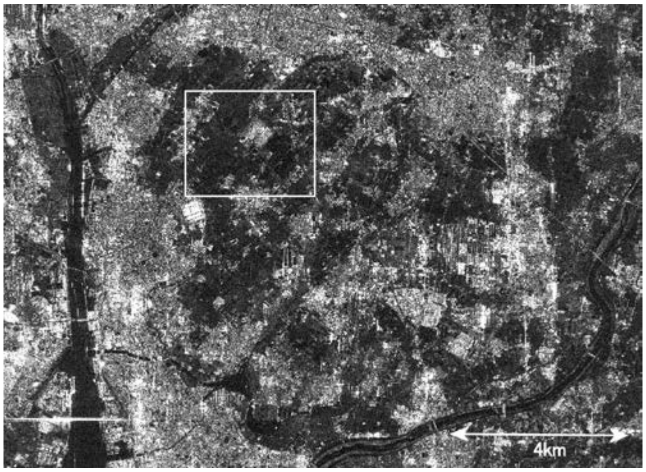


Fig. 2 Expansion image rectangular of Fig. 1 (vicinity of anjo city)

The reason for this is that PALSAR is L band SAR. L band SAR is considered smooth even if the roughness somewhat bigger compared with C or X band SAR sensor such as RADARSAT etc.. Therefore, bare paddy fields are not so difference with fields filled water, because most microwave occur the specular reflection and backscatter is weak.
Fig. 3 shows enlarge image of Fig 2. Most of the farmland in this region was paddy fields, and there are a few orchard of the fig tree. The paddy fields where rice will plant in summer are in the state of bare ground. On the other hand, wheat is cropped some rice paddy fields to reducing rice planting acreage, and the bud comes out and it has grown up to about several cm-10cm. Photo 1 is a picture taken in point ①, and the rice paddy fields in the state of bare ground. Photo 2 is a picture taken in point ② and the fields where cropped wheat. As for the arrow of the various place point, the direction of taking a picture is indicated. Both fields are hardly discernible in the PALSAR image. The microwave of L band with long wavelength penetrates the vegetation of such a size. Therefore, scattering is caused with the soil under that. In addition, backscatter becomes small because it can consider smooth ground where the roughness of the ground is small. Therefore the bare fields and the fields where wheat was planted similarly look dark.
Photo 3 is a picture taken in point ③, and the rice paddy fields filled water. In this region, a new way of farming is experimentally tested. This new way of farming does "puddling and leveling in winter". Usually the puddling and leveling of rice paddy fields carries out in spring. When taking a picture, "puddling and leveling in winter" just done, and paddy fields ware state of filled water or just after "puddling and leveling in winter" where has drained water (Refer to photo 4) in the south region from point ③. These fields which it went on "puddling and leveling in winter" in the south region in point ③④ is a state of filled water or a very flat ground. Therefore, the backscatter of those fields are somewhat smaller than the bare fields and the wheat fields, and look dark little bit in this PALSAR image. The difference between the water bodies and the bare land and the wheat fields is small, and as for fields of puddling and leveling in winter and other fields in similar, the difference is small.
It is conclude that it is difficult to distinguish filled water, puddling and leveling field, from other fields with high accuracy using the difference of this backscatter value in the PALSAR image. However, in the summer, better result is in prospect because almost fields around paddy rice fields grow crops.

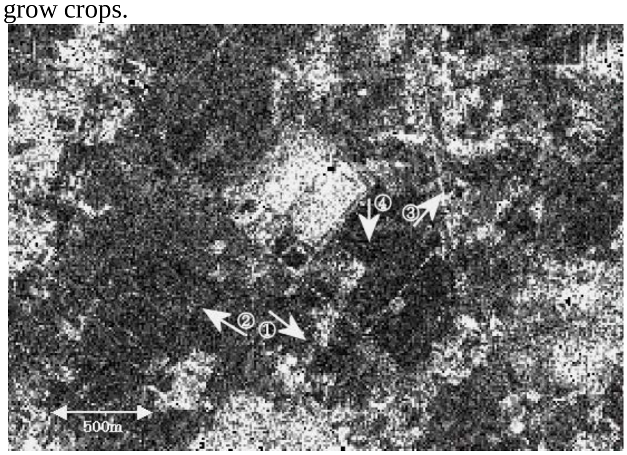


Fig. 3 Photo points and direction (Enlarge image of Fig. 2)

Photo 1. Bare

Photo 2. Wheat

Photo 3. Just Puddling and leveling (filled water)

Photo 4. Just after Puddling and leveling (drained water)

2.1.4 Conclusions

There are some issues that observation of rice paddy fields using SAR, for example Ribbes and Toan(1999)[1], Ishitsuka (2002) [2]etc. Those are mostly use RADARSAT that is C-band sensor. If using L-band SAR, the scattering of paddy fields is different C-band SAR, and it is not use direct same method to monitoring rice paddy fields.

In this time, we conclude that it is difficult to distinguish filled water, puddling and leveling field, and other fields clearly with high accuracy from the difference of backscatter value in the PALSAR image. However, we consider that better result is in prospect in the summer because almost fields around paddy rice fields grow crops. In addition, there is possible to classify if PALSAR combines with the SAR image with different wavelength or the optical sensor image. In this time, PALSAR image used was HH polarization. We consider that the difference of the backscatter value in the wheat fields etc. somewhat grows, and can be classified if the VV polarization can used. In addition, it is necessary to consider incidence angle.

2.2 SUMMER PADDY RICE FIELDS

Japanese government started “Project on use of satellite image for paddy planted area survey” from 2009. In this project, evaluation test carried out in 8cities(About 28,000 fields 3,500ha) using ALOS/PALSAR in 2009. As a result the accuracy of detection that rice planted are 70 to 85%. [3]

3. RICE GROWTH MONITORING

3.1 Materials and method

3.1.1 Study area

The study was carried out in Tsukuba (36° 01' 57" North, 140° 04' 38" East) and surrounding areas, Ibaraki Prefecture, Japan.

In this region, paddy fields start to fill water at late April, then transplanting carried out at early May. Harvesting is usually middle September.

Several paddy fields, alternative upland crops such as wheat and soybeans are cultivated in nominal paddy fields, because the amount of rice production to be reduces.

3.1.2 Data used

PALSAR data ware obtained total 14 scenes in 2007, 11 scenes in 2008 from JAXA.

10m DEM data provide by GSI (Geospatial Information Authority of Japan) ware obtained to use ortho rectification.

Vector data of each paddy fields parcel ware created with head up digitizing over aerial ortho-photo.

3.1.3 Method

Multi temporal PALSAR data (Level 1.5) geo-corrected and ortho-rectified with Japanese 10m DEM using ASF's software “Mapready”, which calculate backscatter coefiicient (σ^0) simultaneously. After that each paddy fields parcel carried out statistical processing using GIS software to compute mean value of σ^0.

We compared the multi temporal PALSAR data with the ground survey data, planted crop and the height of rice, to clarify relationship.

3.2 Results and discussion

Fig. 4 shows temporal change of backscatter coefficient (σ^0) which paddy rice planted fields and alternative crop planted.

The backscatter coefficient is decrease in May. It is consider that filling water lead to this phenomenon. However it is hard to explain increase of June and decrease of August, against rice is growing period.

Thus we tried to select same orbit and mode PALSAR data. The result shows Fig. 5. The anomalous change was not seen in rice planted fields. It is important to note that PALSAR data uniform polarization, orbit, and mode etc. when use multi temporal data.

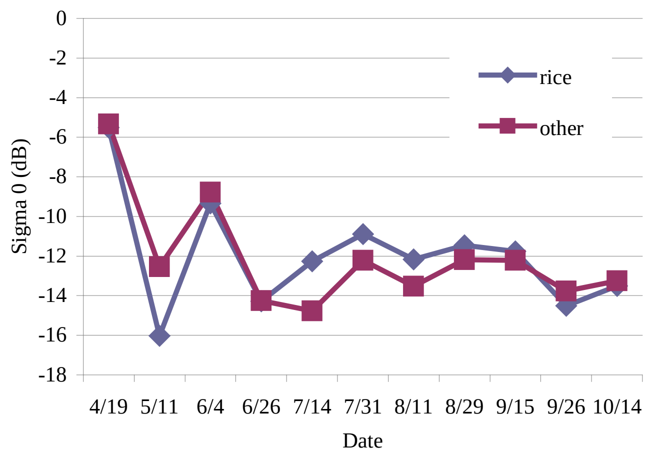


Fig. 4 Temporal change of backscatter coefficient (σ^0) which paddy rice planted fields and other crop planted.

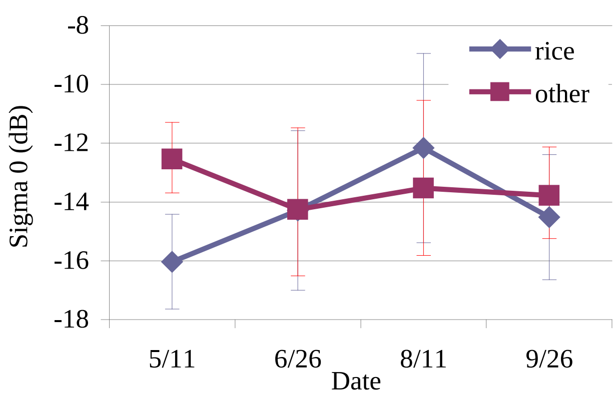


Fig. 5 Temporal change of backscatter coefficient (σ^0) which paddy rice planted fields and other crop planted using same orbit and mode PALSAR data.

Backscatter coefficient (σ^0) of multi temporal PALSAR data, which ware selected same polarization and range direction, compare with height of rice (Fig.6). σ^0 of PALSAR increase about 4 dB in the cultivation period of paddy rice, and correlation was seen in the height of paddy rice and σ^0. However it was difficult to identify planted paddy rice fields with high accuracy because the difference of σ^0 at each paddy fields ware large. It is similar reason, amount of rice growth at each fields could not estimate. It is important that this correlation disappears when use dataset which different polarization or range direction.

The result of 2008 shows Fig.7. We get similar result in 2007, σ^0 of PALSAR increase about 4 dB and correlation was seen in the height of paddy rice in the cultivation period, and the difference of σ^0 at each fields ware large.

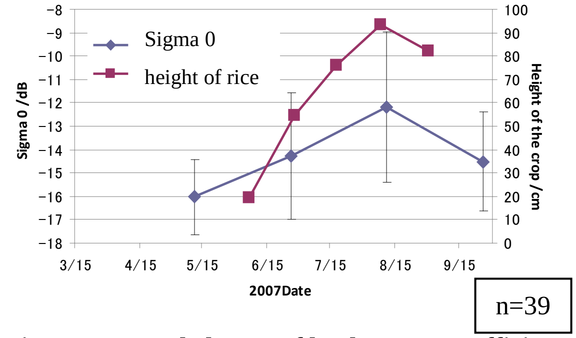


Fig. 1 Temporal change of backscatter coefficient (σ^0) and height of rice in 2007

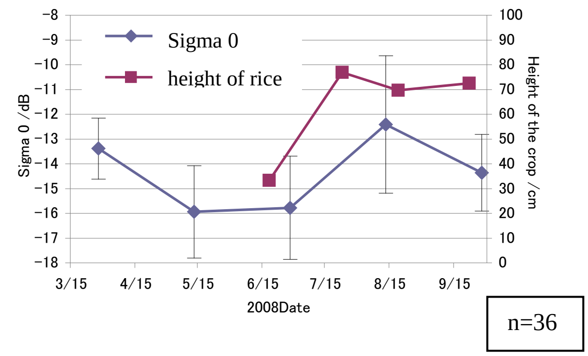


Fig.7 Temporal change of backscatter coefficient (σ^0) and height of rice in 2008

3.3. Conclusion

Backscatter coefficients (σ^0) of PALSAR increase about 4 dB the cultivation period of paddy rice, and correlation was seen in the height of paddy rice and σ^0. However it is difficult to specific planted paddy rice and to estimate the amount of rice growth because the difference of σ^0 at each fields ware large. It is important to note that PALSAR data uniform polarization, orbit, and mode etc. when use multi temporal data.

4 POLARIMETRIC ANALYSIS

4.1 Materials and method

4.1.1 Study area

The study was carried out in Tsukuba and surrounding areas, Ibaraki Prefecture, Japan.

4.1.2 Data used

Full-polarimetric PALSAR data are observed on August 24 and October 09 in 2008. In August, paddy rice is growing on paddy fields. However some paddy fields are another crop, for example soybeans, are growing because government carry out rice product control program. In October, paddy rice is already harvested, and almost rice planted paddy fields covered with residue. On the other hand soybeans are not harvested yet.

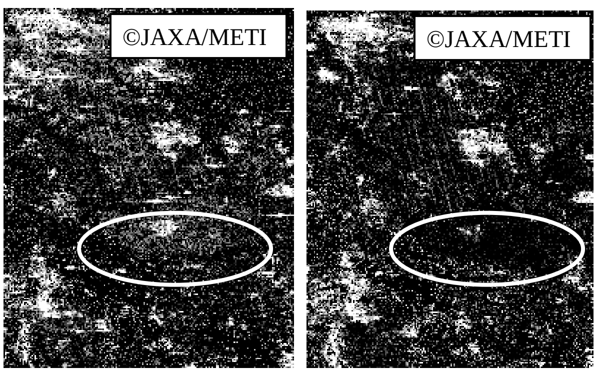
ALOS/AVNIR-2 data observed October 8th in 2008 was used for detect distribution that rice planted area and alternative crops.
Vector data of each paddy fields parcel was created with head up digitizing over aerial photo, and vector data block scale was created with ALOS/AVNIR-2 image.

4.2 Methods

Full-polarimetric PALSAR data (Level 1.1) analyzed using "PolSARpro" developed by ESA.
We compare the results of analysis with the ground survey data, to study scatter characteristics of paddy fields and to evaluate accuracy of the classification.

4.3 Results and discussion

Fig.8 shows double bounce scatter component in Freeman and Durden three components decomposition analysis. In the August image, double bounce scatter component are appear at rice planted paddy fields. On the other hand, the double bounce scatter component decreases in October 09 image (solid line circled area). At August, it is consider that double bounce occur water and rice stem.



08/24/2008 10/09/2008

Fig. 8 Double bounce scatter component

Fig. 9 shows AVNIR-2 image observed October 8th 2008. In this image could detect distribution of rice planted area (white with dark green (white)) and soybeans planted area (red (dark)). This region carried out block rotation system rice and alternative cops. We created polygon vector rice planted blocks and other crops blocks (Fig. 9).
Fig. 10 shows result of Freeman and Durden three components decomposition analysis with block scale vector. We compute mean of three components each block vector.
Fig 11 shows scatter plot of Double and Odd component in Freeman and Durden three components decomposition analysis block scale. This figure suggests that it is possible to separate rice planted area with other crop planted area. In other word, Full-polarimetric PALSAR data has possibility to classify rice planted area with only one scene.
However these blocks are change every year. Therefore classification needs to carry out each parcel scale. Each paddy fields parcel overlaid AVNIR-2 image (Fig. 12)

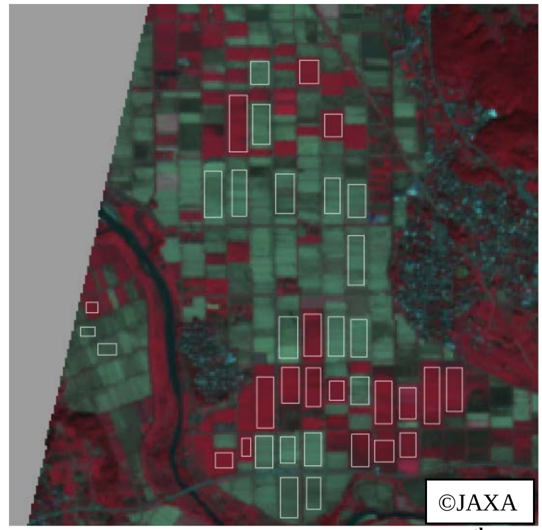


Fig. 9 AVNIR-2 image observed October 8th in 2008 with block scale vector

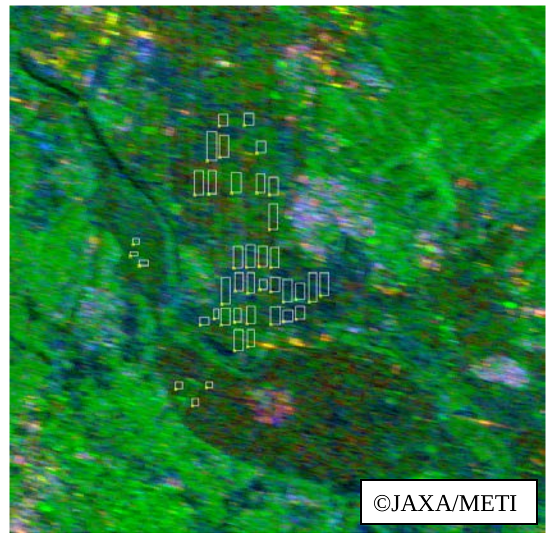


Fig. 10 Result of Freeman and Durden three components decomposition analysis with block scale vector

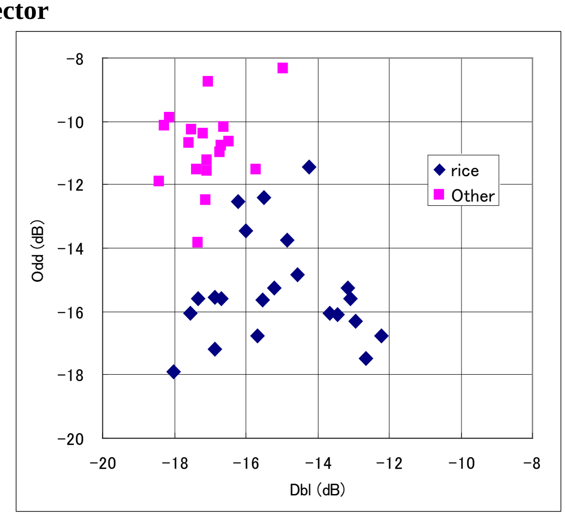


Fig. 11 Scatter plot of Double and Odd component in Freeman and Durden three components decomposition analysis block scale

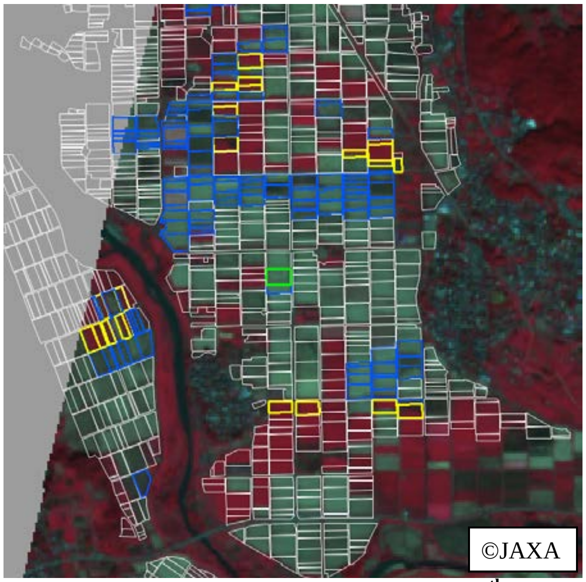


Fig. 12 AVNIR-2 image observed October 8th in 2008 with each paecel vector

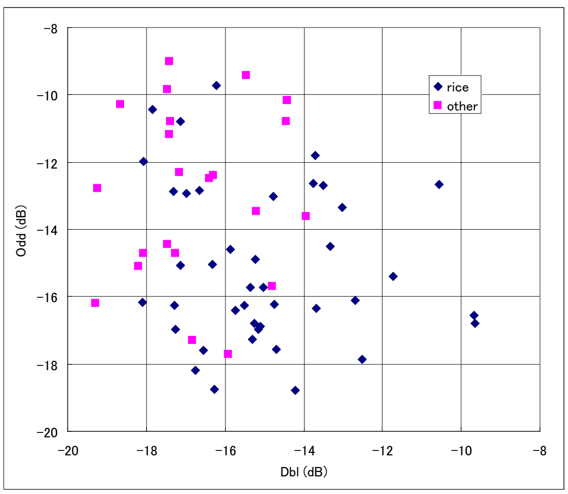


Fig. 13 Scatter plot of Double and Odd component in Freeman and Durden three components decomposition analysis each parcel scale

In the Fig. 12, it is easy to identify rice planted fields and other crop planted fields. Almost these parcels size is target standardization size in Japanese paddy fields. Thus AVNIR-2 has enough spatial resolution for Japanese target standardization size. We compute mean of three components each field parcels vector.

Fig. 13 shows scatter plot of Double and Odd component in Freeman and Durden three components decomposition analysis each parcel scale. This figure suggests that it is hard to separate rice planted area with other crop planted area each parcels scale using PLR data.

Spatial resolution of full-polarimetric mode PALSAR observation is about 30m. Japanese typical paddy fields are 10a to 30a. For example 30a paddy field is 100m by 30m. Therefore resolution of full-polarimetric mode PALSAR observation is not enough almost Japanese paddy fields parcels.

4.4. Conclusion

Full-polarimetric data confer useful information and chance of advanced analysis. Thus there is possibility of determination for rice planted paddy fields when use full-polarimetric PALSAR data. However it is difficult to determinate at each field scale because PLR mode spatial resolution is not enough for Japanese typical paddy fields. Therefore we expect resolution of ALOS-2 sensor.

5 CONCLUSIONS

The purpose of the research is to clarify the problem and effectiveness when measure the planted area of rice paddy fields using ALOS/PALSAR. It is summarize conclusion as follows.

- PALSAR is difficult to distinguish filled water or puddling and leveling field from other fields with high accuracy using the difference of backscatter value. PALSAR detect filled water field 70 to 85%.
- Backscatter coefficients (σ^0) of PALSAR increase about 4 dB the cultivation period of paddy rice, and correlation was seen in the height of paddy rice and σ^0. However it is difficult to estimate the amount of rice growth because the difference of σ^0 at each fields ware large.
- PALSAR data uniform polarization, orbit, and mode etc. when use multi temporal data.
- There is possibility of determination for rice planted paddy fields when use full-polarimetric PALSAR data. However it is difficult to determinate at each field scale because PLR mode spatial resolution is not enough for Japanese typical paddy fields.

PALSAR indicate several possibilities to apply monitoring of paddy fields. However spatial resolution is not enough Japanese paddy fields. Therefore we expect ALOS-2 sensor.

Acknowledgement

This research is conducted under the agreement of JAXA Research Announcement titled ‘The scatter characteristic of rice paddy fields using L band multi polarimetric satellite SAR observation’ (JAXA-365).

REFERENCE

[1] Ribbes, F. and Toan T.L.1999, Rice field mapping and monitoring with RADARSAT data. International Journal of Remote Sensing, 20(4), pp. 745-765.

[2] Ishitsuka, N., Saito, G., and Ogawa, S., 2002, Area Determination of Rice Paddy using Satellite SAR Data.Advances in the Astronautical Sciences, 110, pp.223-231.

[3] Ministry of Agriculture, Forestry and Fisheries, “ The report of Project on use of satellite image for paddy planted area survey in FY2009”, an article not for sale and publish, (in Japanese).